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The effect of the Doclens on detectability of features in the snow during overcast conditions

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Abstract
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THE EFFECT OF THE DOCLENS ON DETECTABILITY OF FEATURES IN THE SNOW DURING OVERCAST CONDITIONS

A THESIS

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INTRODUCTION

The "DOCLENS" (Dr. Oakley's Contrast) is a magenta-colored absorptive coating placed on a hard-resin ophthalmic lens. This tint was developed by Dr. K. H. Oakley of Bend, Oregon. It is available in three densities and may be obtained from an ophthalmic laboratory in Portland, Oregon, the sole supplier.[a]

The DOCLENS was developed as a contrast enhancing filter to permit skiers to better detect terrain contours in the snow during overcast or "white-out" conditions, or for airplane pilots flying in similar conditions of flat light, haze, or smog. Dr. Oakley has received many testimonials from experienced skiers who report the tint affords them improved ability to detect features on the surface of the snow, and from commercial airline pilots who report improved visibility of terrain features in a haze condition.

The DOCLENS has also been found useful by foresters to detect small columns of smoke rising from incipient forest fires, and improved detection of insect infested trees among healthy trees.

Dr. Oakley also reports that he has found the tint helpful in reducing the hazy vision of patients with incipient cataract.

Wyszecki (1956) attempted to calculate whether or not any specific color of absorbing glass would enhance the ability to detect sudden changes of elevation in the snow field. The theoretical maximum of brightness contrast would be obtained by

[a] Opti-Craft, Incorporated, 412 S.W. 12th Avenue, Portland, OR 97208

using a filter which transmits mostly longer visible wavelengths such as a red glass, however, this maximum was not considered a significant improvement, and he concluded that no specific color of absorbing lens would improve this detectability.

Burge and Thorn (1974) did a computer simulation of the effects of tinted lenses on detection of features in a snow environment. Wyszecki's formulas were used to calculate the luminous contrast and color contrast of nine different tints and no filter. As predicted by Wyszecki, the two red Wratten filters showed the most luminous contrast, followed by the DOCLENS #2 and the Polaroid yellow. However, in the color contrast calculations, the DOCLENS #2 showed the greatest value, followed by the B & L Smoke No. 4 and no glass filter. The red Wratten filters showed the worst color contrast of the nine filters. The differences in contrast, however, are so slight that the conclusion was that the casual skier would not really be provided with any noticeable enhancement of contrast.

Everson and Levene (1973) measured the human contrast sensitivity function at various photopic luminance levels using a neutral gray filter, a yellow filter, the DOCLENS filter, and no filter. Their conclusion was that none of the tinted filters permitted more significant detection than no filter at all.

This study sought to determine whether or not skiers could better detect features in the snow under overcast conditions using the DOCLENS #2 tint, as compared with a neutral gray filter of equal transmittance.

METHOD

Two different experiments were conducted at the Ski Bowl Ski Area near Mt. Hood, Oregon.

Experiment I was a subjective preference test in which a subject viewed a natural scene from a building porch (as shown in Photo #1) while looking through the DOCLENS tint, and alternately through a neutral gray tint of equal transmittance. The 37 subjects were asked two questions: First, which of the two tints allow you to see further into the fog with more contrast of features? Second, which tint would you prefer in this weather condition? The illumination was measured with a GE Type 213 light meter pointed toward the viewing scene. It measured 800 fc. The sky was completely overcast with the viewing scene partially blanketed with fog as shown in Photo #1.

Experiment II was performed twice, the first time with 2500 fc of sky illumination and 2220 fc of illumination from the target area. The sky was a high, but complete overcast. This was part II-A.

Part II-B, the second run, was performed with 1000 fc of sky illumination and 850 fc of illumination from the target area. The sky was a very low, complete overcast with some fog.

Part II-A was made with nine subjects, and part II-B was made with nine different subjects. Experiment II was a test of how many features in the snow could be detected while looking through the DOCLENS #2, and with a neutral gray tint of equal transmittance.

The apparatus was set up on a flat snow field which sloped up against the side of an A-frame building. Ther were no colors in the surrounding area except the grayish shingles of the building behind the target area.

The grid pattern punch was rectangular, 6 inches by 1 3/4 inches, and made of styrofoam. It contained seven rounded grooves, each of which was 3/8 inch deep. The grid pattern punch is shown drawn actual size in Fig. 1.

Twenty grid patterns wre punched into the smooth, featureless snow within the target area, which was rectangular, 3 feet by 6 feet, and sloped toward the observer at a 45 degree angle. The testing distance was 18 feet.(Fig. 2 & 3).

The location as well as the vertical or horizontal arrangement of the patterns was random. The various depths of the patterns punched into the snow varied randomly from approximately 2 inches to 1/8 inch, thus some of the patterns were easily seen, while some were below detection threshold (Photo 2 & 3).

The subject was allowed to look around the mountain area through the tinted lenses to be tested for 15 seconds to allow initial adaptation. The subject was not allowed to view the target area during this adaptation. Then he was positioned facing the target area and given these instructions:
"Count the number of small grid patterns that you see in the snow within the large rectangular area. Only count a pattern if you are sure that it is there." The viewing time was limited to 45 seconds. After the subject reported the number of patterns

he detected, the other tint was placed before his eyes and the test repeated with these instructions: "Once again count the number of grid patterns that you are sure you see, but do not be influenced by how many you saw through the first lenses. Only count the patterns you actually see." The order of the two tints was alternated between subjects. Following both trials, the subjective preference of tint was asked.

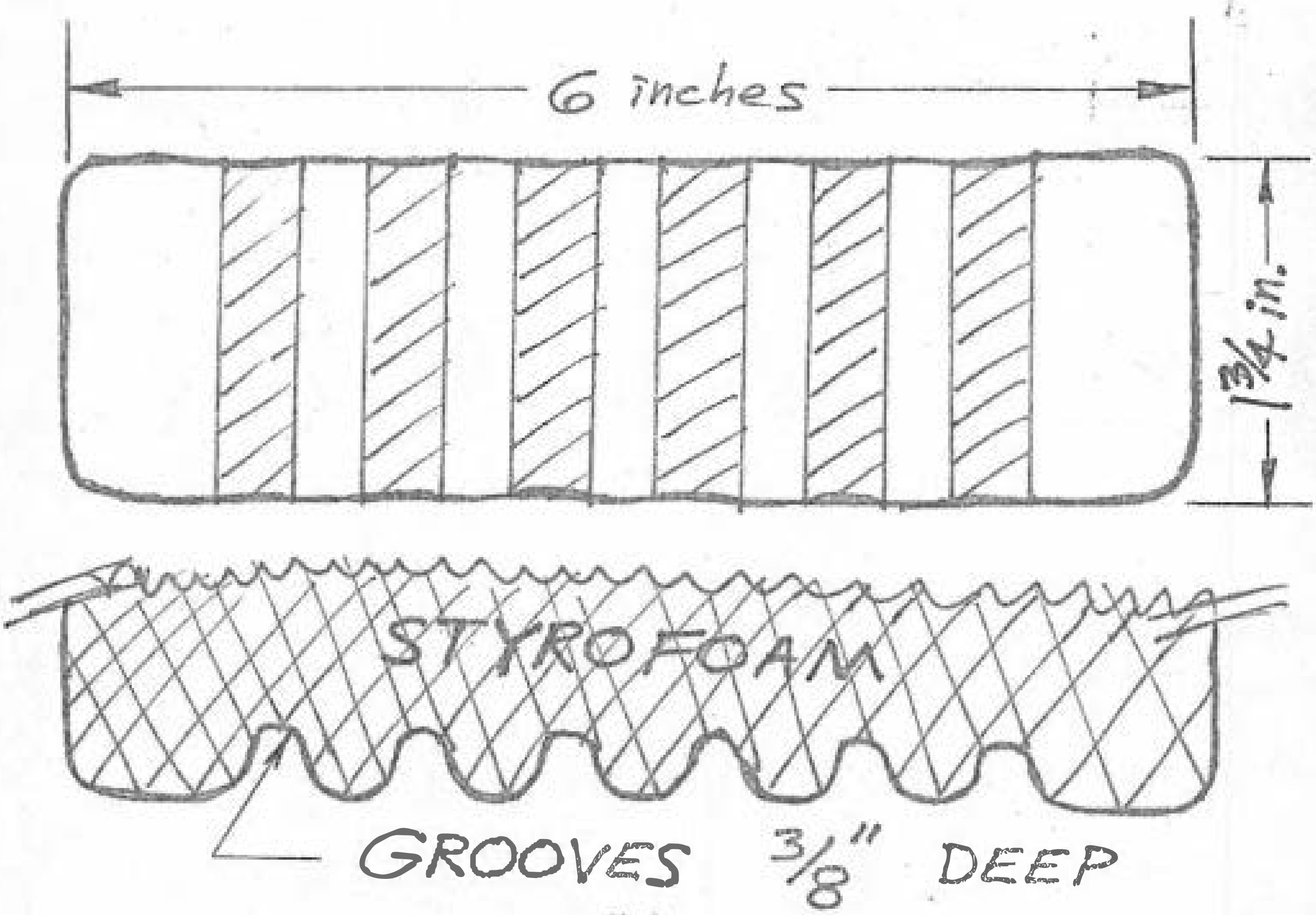
The filters used for all experiments were dyed hard-resin plano ophthalmic lenses. One pair of lenses was the DOCLENS #2, and the control pair was a neutral gray. The transmittance of the filters was measured using a 6500-6700°K. source with a measuring photocell corrected to the standard observer. The pair of DOCLENS #2 measured 30% and 31%, and the pair of neutral gray lenses measured 30% and 32% transmittance.

PHOTO # 1

PHOTO # 2

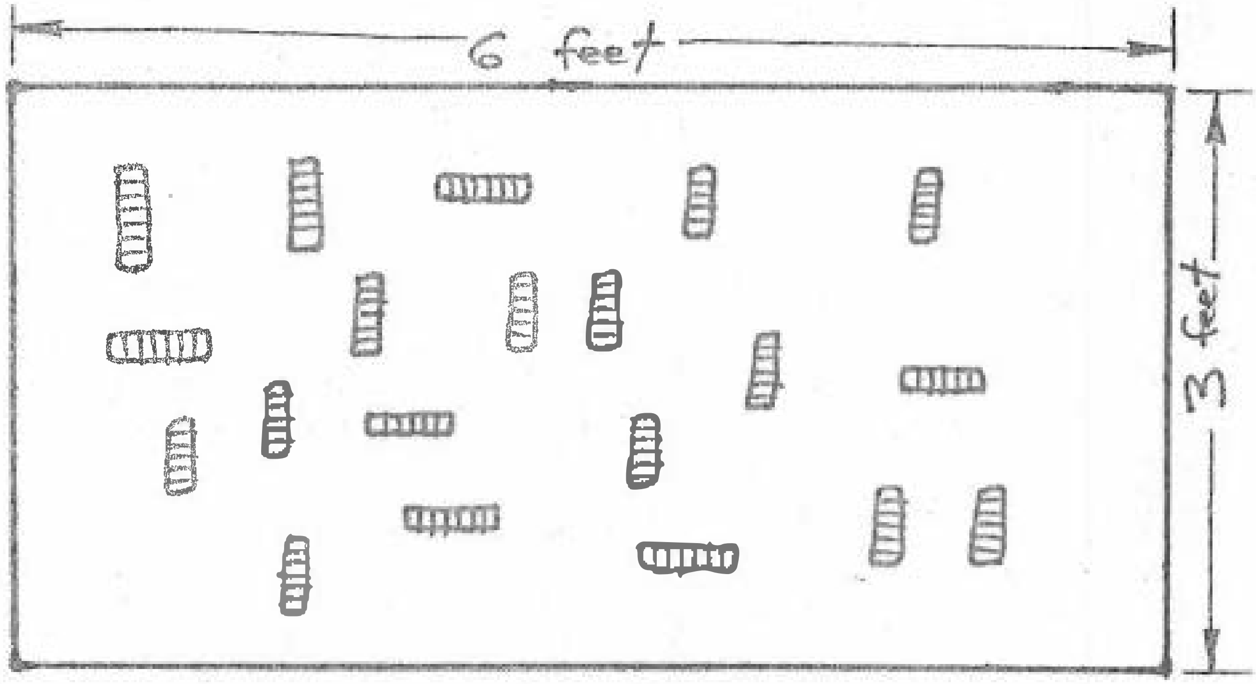
PHOTO # 3

FIG. 1

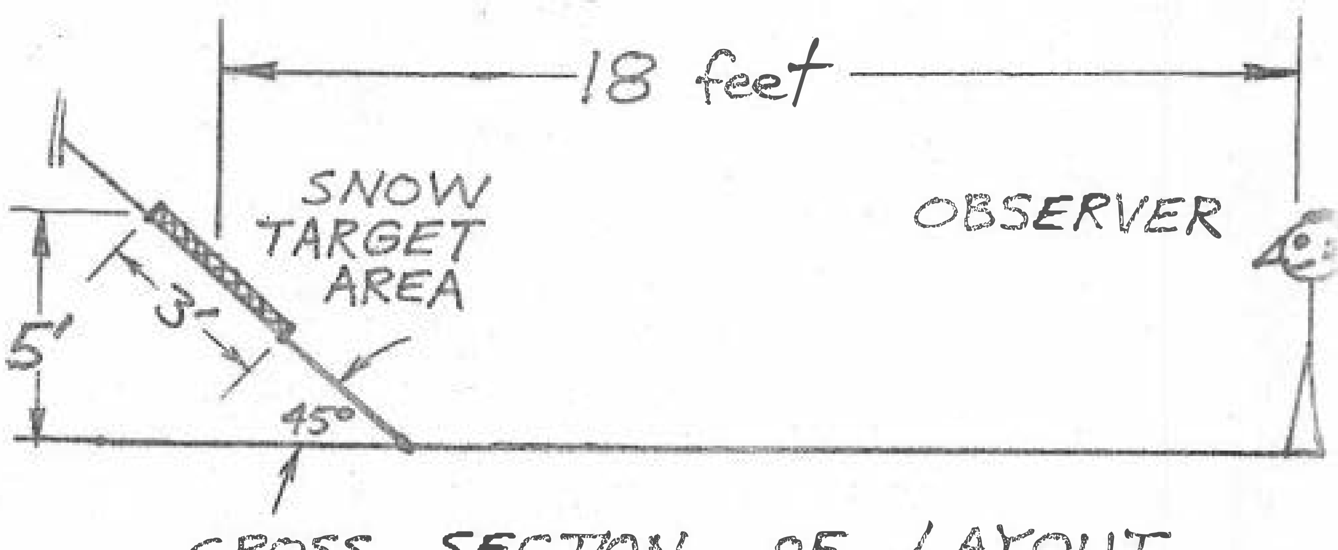


DETAIL OF SNOW TARGET
GRID PATTERN PUNCH

FIG. 2



DETAIL OF SNOW TARGET AREA WITH RANDOM ARRANGEMENT OF 20 GRID PATTERNS



CROSS SECTION OF LAYOUT

FIG. 3

RESULTS

EXPERIMENT I:

S = Same, No Difference

D = DOCLENS #2

G = Neutral Gray

	SUBJECT	AGE	CORRECTIVE LENSES	SUBJECTIVE BEST CONTRAST	PERSONAL PREFERENCE
1.	C.M.	24	None	G	G
2.	D.H.	23	Glasses	G	G
3.	C.F.	21	Contacts	G	G
4.	T.A.	40	Glasses	D	D
5.	J.B.	37	None	S	G
6.	D.K.	38	Glasses	S	D
7.	R.N.	21	Glasses	D	D
8.	R.T.	42	Glasses	G	G
9.	J.C.	29	Glasses	S	D
10.	C.J.	22	None	G	G
11.	D.P.	24	Contacts	D	G
12.	V.D.	22	None	D	D
13.	K.N.	16	None	D	D
14.	R.K.	16	None	G	G
15.	J.H.	15	None	D	D
16.	C.H.	16	None	G	G
17.	M.W.	19	None	G	G
18.	D.K.	22	None	S	G
19.	R.J.	15	None	S	D
20.	M.A.	14	None	D	D
21.	J.A.	17	None	D	D
22.	D.S.	17	None	D	D
23.	J.M.	18	None	D	D
24.	B.E.	20	None	D	D
25.	J.W.	19	None	D	D
26.	K.A.	16	None	D	D
27.	S.B.	15	None	D	D
28.	E.A.	78	None	D	D
29.	D.A.	35	Glasses	S	D
30.	C.A.	8	None	D	D
31.	K.K.	16	None	G	G
32.	M.K.	13	None	D	D
33.	M.A.	17	Glasses	G	G
34.	S.C.	17	Glasses	G	G
35.	T.K.	12	None	G	G
36.	J.W.	17	None	G	G
37.	K.W.	17	None	S	G
				D = 17	D = 20
				G = 13	G = 17
				S = 7	

EXPERIMENT II-A: HIGH OVERCAST

ILLUMINATION: SKY = 2500 fc, TARGET = 2220 fc

	SUBJECT	AGE	YEARS SKIING	CORRECTIVE LENSES	# OF PATTERNS DETECTED DOCLENS	# OF PATTERNS DETECTED GRAY	SUBJECTIVE PREFERENCE OF TINT
1.	L.Z.	21	0	None	16	16	DOCLENS
2.	J.H.	20	1	None	17	16	DOCLENS
3.	R.N.	19	10	Contacts	14	14	DOCLENS
4.	S.N.	16	1	Contacts	15	11	DOCLENS
5.	R.W.	19	4	None	17	14	Doclens
6.	C.S.	17	1	None	8	8	DOCLENS
7.	J.V.	14	1	None	8	10	GRAY
8.	L.L.	19	7	None	9	9	DOCLENS
9.	L.D.	21	6	None	9	9	DOCLENS
					113 TOTAL	107 TOTAL	DOCLENS=8 GRAY = 1

EXPERIMENT II-B: LOW OVERCAST

ILLUMINATION: SKY = 1000 fc, TARGET = 850 fc

	SUBJECT	AGE	YEARS SKIING	CORRECTIVE LENSES	# OF PATTERNS DETECTED DOCLENS	# OF PATTERNS DETECTED GRAY	SUBJECTIVE PREFERENCE OF TINT
1.	B.C.	19	6	None	13	17	GRAY
2.	T.M.	20	2	None	15	18	GRAY
3.	D.T.	15	4	None	18	16	DOCLENS
4.	K.H.	15	1	None	14	15	GRAY
5.	R.A.	16	4	None	11	11	GRAY
6.	B.C.	16	4	None	7	6	DOCLENS
7.	S.T.	24	1	None	15	13	DOCLENS
8.	W.J.	24	4	Glasses	13	12	DOCLENS
9.	J.L.	18	1	None	10	10	DOCLENS
					116 TOTAL	118 TOTAL	DOCLENS = 5
							GRAY = 4

STATISTICS

"t - TEST" ANALYSIS FOR PAIRED OBSERVATIONS:

EXPERIMENT II-A:

SUBJECT	# DOCLENS	# GRAY	d DIFFERENCE	d^2
1.	16	16	0	0
2.	17	16	1	1
3.	14	14	0	0
4.	15	11	4	16
5.	17	14	3	9
6.	8	8	0	0
7.	8	10	-2	4
8.	9	9	0	0
9.	9	9	0	0
			T = 6	T = 30

Mean Difference = .667 more patterns detected with DOCLENS

Standard Deviation = 1.80

t = 1.11

For significance at the .05 level, t must be 1.86 or greater.

Therefore, there is no significant difference.

EXPERIMENT II-B:

SUBJECT	# DOCLENS	# GRAY	d DIFFERENCE	d^2
1.	13	17	-4	16
2.	15	18	-3	9
3.	18	16	2	4
4.	14	15	-1	1
5.	11	11	0	0
6.	7	6	1	1
7.	15	13	2	4
8.	13	12	1	1
9.	10	10	0	0
			T = -2	T = 36

Mean Difference = -.222 more patterns detected with DOCLENS

Standard Deviation = 2.11

t = -0.32

For significance at the .05 level, t must be 1.86 or greater.

Therefore, there is no significant difference.

DISCUSSION

In comparing the ability to detect small snow features when looking through the DOCLENS and through a neutral gray of equal transmittance, there was no significant difference between the two filters under the test conditions.

It is interesting to note, however, that with the higher overcast and brighter illumination, the subjective responses in favor of the DOCLENS are very strong. Several subjects who detected an equal number of features in the two test trials insisted that they could see much better with the DOCLENS when they viewed the entire surrounding terrain.

There seems to be a psychological effect to the magenta-colored tint of the DOCLENS. Several subjects who preferred the neutral gray felt that the DOCLENS was "too bright", yet both were equal in transmittance. Some subjects preferred the DOCLENS because they didn't like "dark sunglasses".

The introduction listed several reported advantages to the DOCLENS. I feel there are advantages to the filter with certain conditions related to the colors of the objects in view and the spectral transmission function of the DOCLENS. As seen from this curve (appendix), the filter passes mostly longer wavelengths, sharply attenuates the medium green wavelengths, and again passes a significant amount of shorter wavelengths before attenuating the ultraviolet. This gives rise to several possible means of enhancing contrast. Being basically a reddish tint passing mainly longer visible wavelengths, it would act as a theoretical maximum enhancer of luminous contrast according to Wyszecki, without the severe color distortions of a pure red or yellow filter, due to the significant amount of shorter blue-violet wavelengths transmitted by the DOCLENS.

Another possibility of contrast enhancement could be from a binocular stereo effect known as chromostereopsis. This is due to the chromatic aberration of the eye. This phenomenon has been shown to make reds and blues appear at different distances stereoscopically, when both are actually equidistant to the observer. The magnitude and direction of this binocular effect appear to depend on the prismatic effects of the observer's eyes, which vary among individuals as reported by Kohler (1962).

When viewing white clouds against a blue sky through the DOCLENS, many observers report that the clouds seem to "stand out" closer in depth than when viewed without the filter. The clouds seem to take on a pinkish color while the sky appears to become a much darker blue-violet. I feel a possible explanation for this "depth effect" is the chromatic aberration which occurs monocularily in each eye, rather than the binocular effect. The blue light focuses in front of the retina and the red light behind in the emmetropic eye. This may be perceived by the observer as the red being closer in space and the blue further away, as a monocular cue rather than chromostereopsis. This could also explain why the effect works monocularily.

In a skiing situation, if there was enough illumination greater in the blue end of the spectrum, the shadows in the snow would appear a deeper blue-violet through the DOCLENS, and the surface snow a reddish-pink similar to the cloud phenomenon. If the sky was sufficiently overcast, this effect would be reduced. This could possibly explain why the experiment showed the least difference between the two filters during the low overcast and fog conditions, as compared to the high overcast with much brighter illumination.

A combination of any or all of these possible hypotheses of contrast enhancement may be too small to be of any practical importance. If only detection were involved, the effects, if any, would most likely not be useful. However, a skier or a pilot is not simply trying to detect features in the terrain, but is attempting to make complex judgements about these features so that he may react as quickly and precisely as possible to them. We must not conclude that tints which may provide a trivial enhancement for the sitting observer are not useful to the racing skier or flying pilot.

Due to the extensive amount of favorable subjective responses, there must be some contributing cause whether it be psychological or physiological. Further study of these hypotheses might provide more concrete evidence as to the actual nature of the observed effects of the DOCLENS.

CONCLUSIONS

The DOCLENS #2 and a neutral gray filter of equal transmittance were compared as to their ability to enhance the detection of small features in the snow under both high and low overcast weather conditions.

The results showed no significant difference between the two filters under the test conditions.

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4. Kohler, Ivo. Experiments With Goggles. Scientific American, May, 1962.

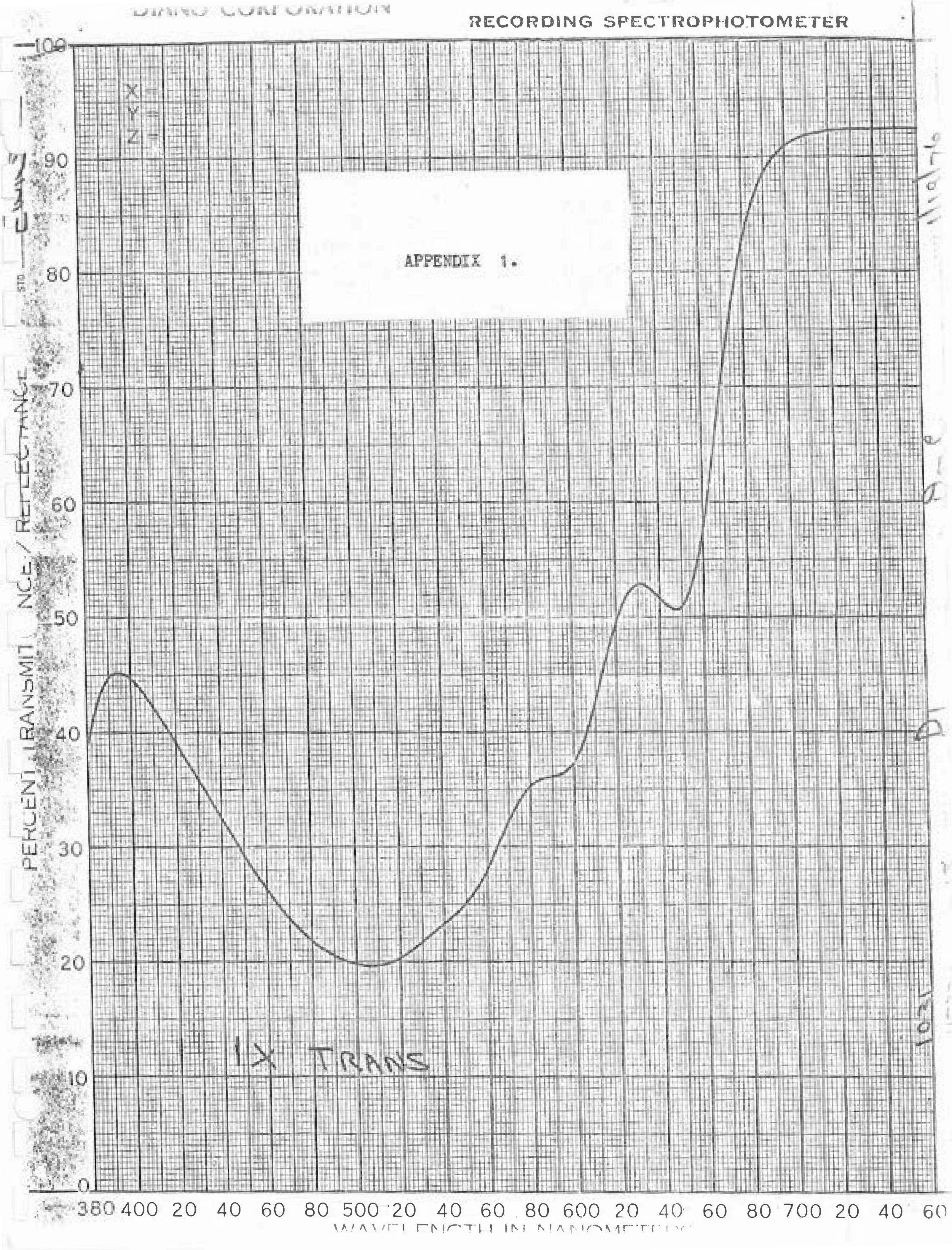
APPENDICES:

1. Transmission Curve DOCLENS #1

2. Transmission Curve DOCLENS #2

3. Transmission Curve DOCLENS #3

4. Comparison of the Eye Sensitivity to the Illuminant with and without the DOCLENS Filter


RECORDING SPECTROPHOTOMETER
X =
Y =
Z =
APPENDIX 1.
PERCENT TRANSMITTANCE / REFLECTANCE
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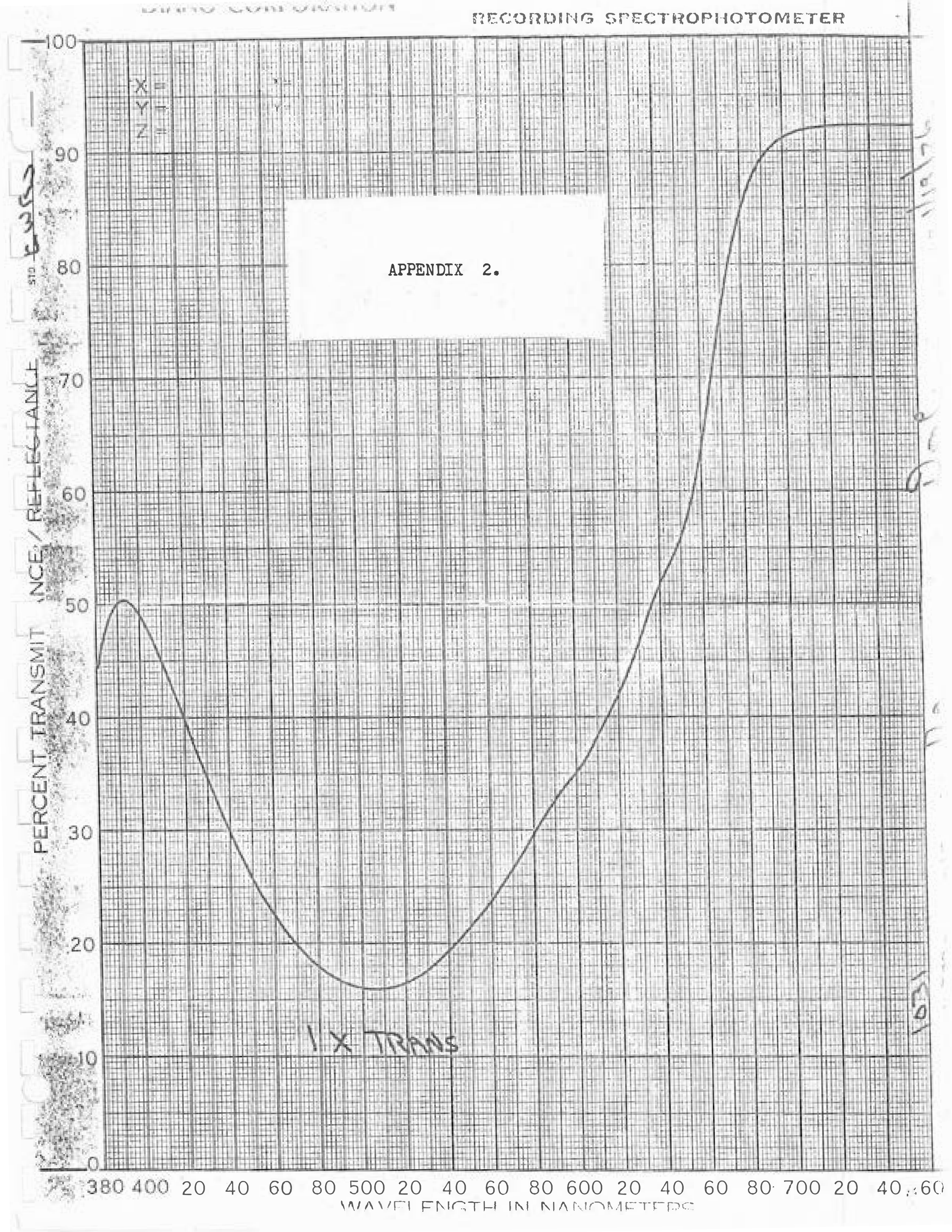
380 400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40 60
1X TRANS

APPENDIX 2.


RECORDING SPECTROPHOTOMETER
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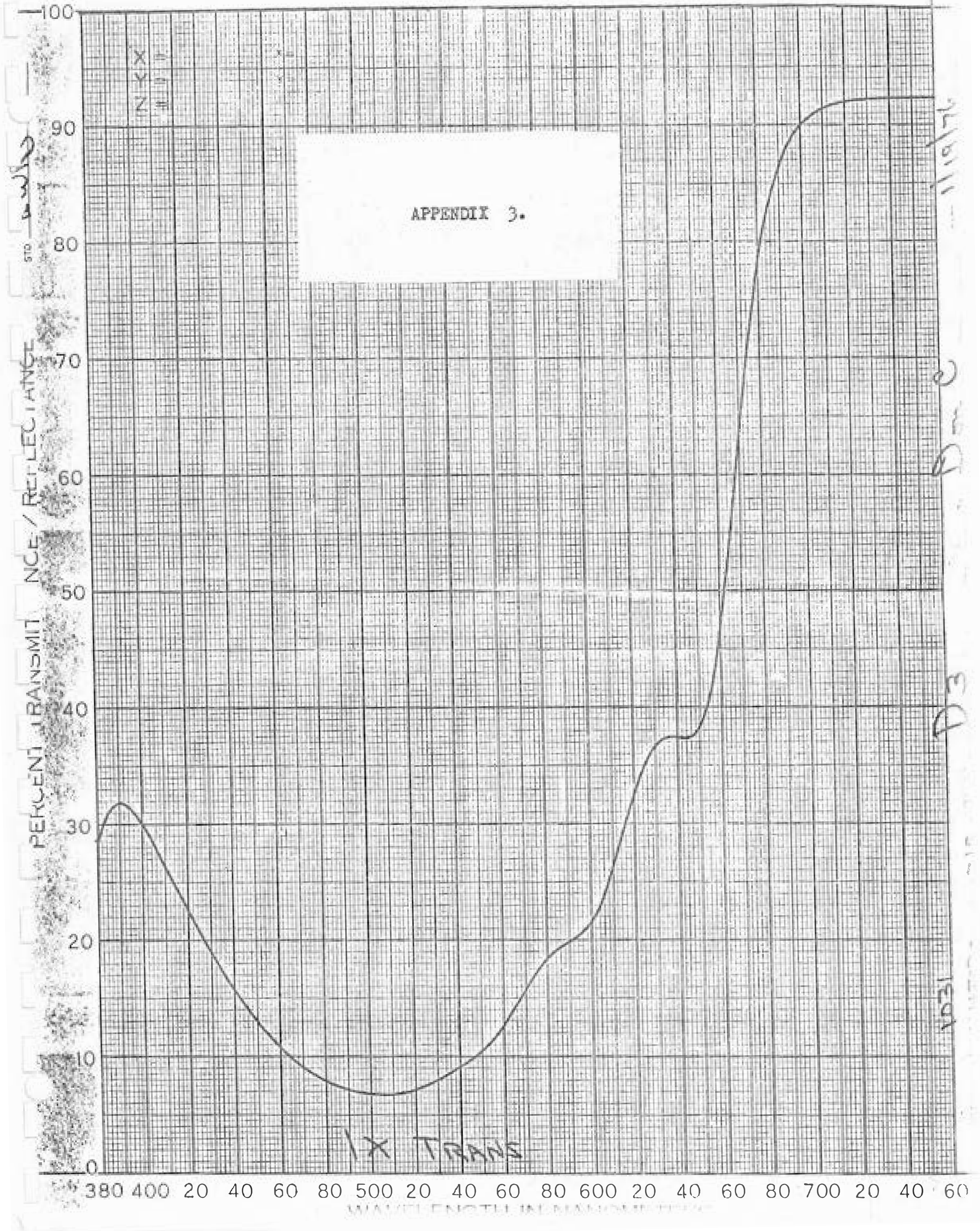
WAVELENGTH IN NANOMETERS

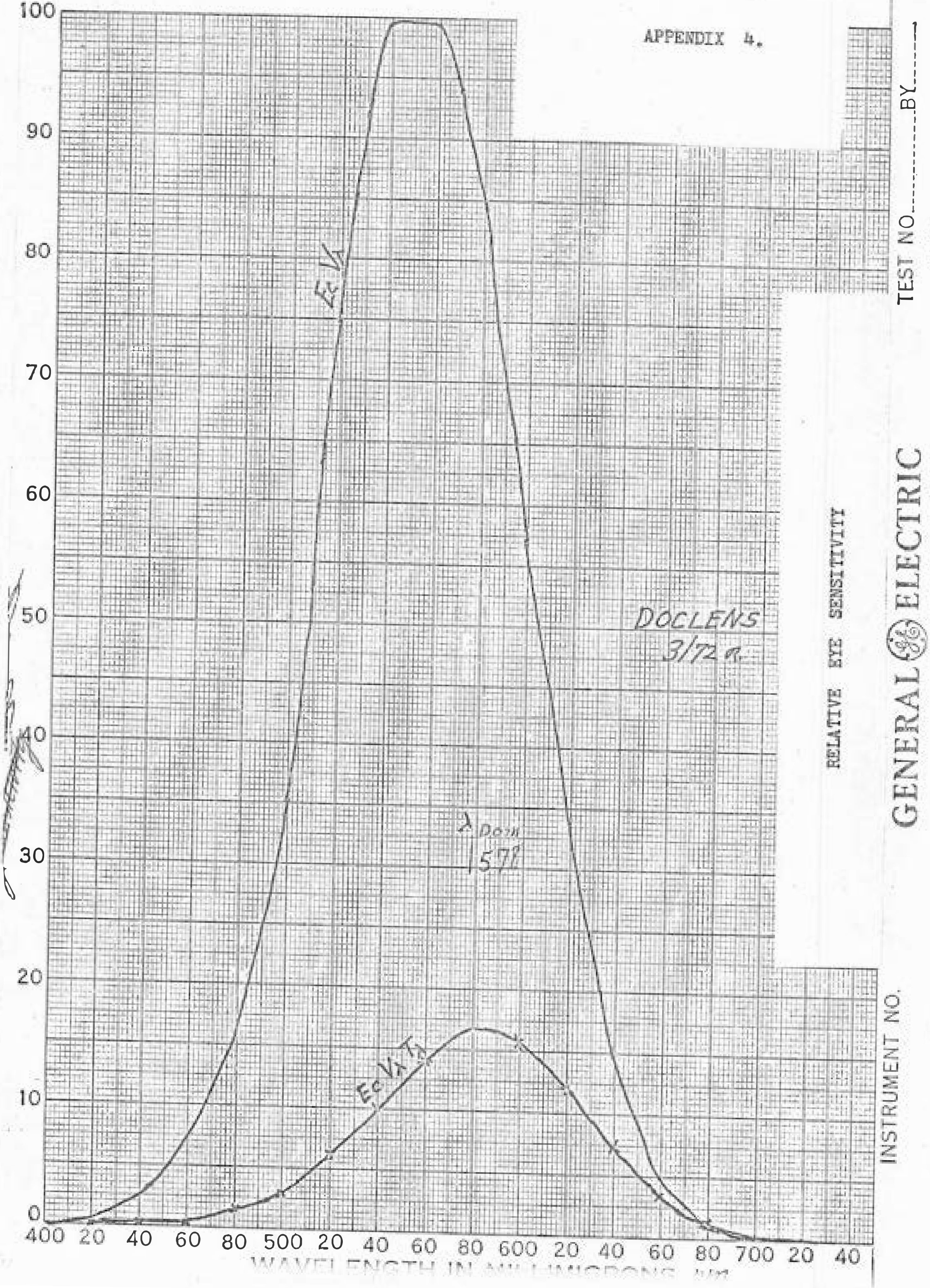
DIANO CORPORATION

RECORDING SPECTROPHOTOMETER

APPENDIX 3.



APPENDIX 4.



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DOCLENS
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RELATIVE EYE SENSITIVITY
GENERAL ELECTRIC
TEST NO.
BY
INSTRUMENT NO.